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<b>(21) International Application Number:</b> PCT/SE96/00234 <b>(22) International Filing Date:</b> 21 February 1996 (21.02.96)  <b>(30) Priority Data:</b> 9500791-0                      6 March 1995 (06.03.95)                      SE  <b>(71) Applicant (for all designated States except US):</b> TETRA LAVAL HOLDINGS & FINANCE S.A. [CH/CH]; Avenue Général-Guisan 70, CH-1009 Pully (CH);  <b>(72) Inventor; and</b> <b>(75) Inventor/Applicant (for US only):</b> JANSSON, Claes [SE/SE]; Sandiljevågen 12, S-297 00 Degeberga (SE).  <b>(74) Agent:</b> CLIVEMO, Ingemar, Alfa Laval AB, S-147 80 Tumba (SE).		<b>(81) Designated States:</b> JP, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).  <b>Published</b> <i>With international search report.</i>
<b>(54) Title:</b> STACK OF SEPARATION DISCS FOR CENTRIFUGAL SEPARATOR		
<b>(57) Abstract</b>		
<p>A disc stack of frustoconical separation discs designed to be mounted in a centrifugal rotor comprises separation discs of two different kinds (13, 14) with respect to the shape permanence of the material out of which they are made, e.g. plastic and metal, respectively.</p>		
<p>The diagram illustrates a stack of separation discs, labeled 2, viewed from an angle. The stack consists of multiple layers of discs. Some discs are labeled 13 and others 14, indicating two different types. Discs 13 appear to have a smooth surface, while discs 14 are shown with a hatched or textured pattern, likely representing a different material or shape. The discs are arranged in a slightly offset manner to show the stack's depth.</p>		

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Stack of separation discs for centrifugal separator

A certain type of centrifugal separators intended for separation of liquids or separation of particles from a liquid has a rotor, in the separation chamber of which there is arranged a stack of frusto conical separation discs. These separation discs normally are arranged coaxially with the rotational axis of the rotor and divide the separation chamber in a lot of thin flow spaces for the liquid or liquids to be subjected to centrifugal separation. A centrifugal separator of this type is shown for instance in US-A-4 191 325.

Traditionally, separation discs for a centrifugal separator of this type have been made of thin sheet metal. To serve as spacing members between adjacent separation discs strips or small round discs also made of thin sheet metal have been fastened onto the separation discs by welding or in some other way - normally on the upper or under sides of all the separation discs.

Already long ago, e.g. in US-A-3 335 946, it was suggested that frusto conical separation discs should be made of plastic material, whereby they would become much cheaper than separation discs made of metal. It was pointed out that plastic discs would not have the same strength as metal discs, but that the small specific weight which could be given to plastic discs would mean that such discs would not be subjected to destroying large centrifugal forces during the operation of the centrifugal separator. Thus, it was considered that the liquid being under centrifugation in the centrifugal rotor, which liquid should have a density of the same magnitude as that of the plastic discs and in which liquid the separation discs should be present during the

operation of the centrifugal rotor, would be able to hydraulically lift the separation discs so that they would not be subjected to harmful centrifugal forces.

5 Theoretically this reasoning is possibly correct, but for practical use of separation discs made of plastic it is without any particular interest. As a rule, namely, each centrifugal separator has to be designed in a way such that its rotor can be rotated at full speed even  
10 without any liquid being present in the separation chamber. In practice it has proved difficult or impossible, particularly in connection with large centrifugal separators and/or in connection with relatively large rotational speeds, to prevent undesired deformation of  
15 the separation discs if these have been made of plastic.

The object of the present invention is to provide a disc stack of frusto conical separation discs, which is designed for a centrifugal separator of the above dis-  
20 cussed type and which both is less expensive than conventional disc stacks having separation discs made of metal and is composed of separation discs which, without becoming substantially deformed, can resist centrifugal forces coming up during operation of a centrifugal rotor  
25 irrespective of whether the latter contains liquid or not.

This object can be achieved according to the invention by a disc stack characterized in that the separation  
30 discs are of two different kinds with respect to their shape permanence, a separation disc in at least part of the disc stack having a relatively large shape permanence and being situated between two separation discs having a relatively small shape permanence, the last  
35 mentioned separation discs being made of a non-metallic

material.

It is presumed in this connection that separation discs made of a non-metallic material and having a relatively small shape permanence are substantially cheaper to produce than separation discs having a relatively large shape permanence.

By the expression "shape permanence" it is meant here the rigidity of the separation discs or the ability of the separation discs to mechanically resist deformation as a consequence of centrifugal forces to which they are subjected under use in a centrifugal rotor.

The expressions "relatively large shape permanence" and "relatively small shape permanence" are intended to indicate in this connection only that the shape permanence of the separation discs of one kind is larger or smaller, respectively, than the shape permanence of the separation discs of the other kind.

In a disc stack according to the invention separation discs of a first kind having a relatively large shape permanence give mechanical support - through spacing members - to separation discs of a second kind having a relatively small shape permanence, so that the latter discs will not be deformed by centrifugal forces during operation of the centrifugal rotor.

Upon need every second separation disc may be of said first kind and the other separation discs of said second kind, but preferably several separation discs having a relatively small shape permanence are arranged between two adjacent separation discs having a relatively large shape permanence. Thereby, large cost savings may be

obtained simultaneously as the total weight of a disc stack can be made small.

5 The choice of material for the different kinds of separation discs may be dependent on various factors, such as the size of expected centrifugal forces or the kind of liquid or particles which can be expected to get into contact with the separation discs.

10 Preferably, sheet metal is chosen for said first kind of separation discs and some plastic material for said second kind of separation discs. However, it is possible to make the separation discs, which are to have a relatively large shape permanence, out of for instance  
15 carbon or glass fibre reinforced plastic, whereas the other separation discs are made cheaper by being produced by unreinforced plastic.

20 If it is desired for some reason to have one of the kinds of separation discs made of different material, this is intended to fall within the scope of the present invention. Falling within the scope of the invention will also a disc stack including, for some reason, two or several separation discs having a relatively large  
25 shape permanence and being arranged between two adjacent separation discs having a relatively small shape permanence.

30 The previously mentioned spacing members between the separation discs may be of any suitable kind. They may be made in one piece with the separation discs or be fastened onto these in some suitable way, such as by welding, soldering or gluing. Alternatively they may be releasably mounted between the separation discs. They  
35 also may have any suitable shape. If they are elongated

they may have a straight or curved form. In addition to a spacing function the spacing members may have a flow conducting function.

- 5 The invention will be described below with reference to the accompanying drawing, in which fig 1 shows an axial section of a centrifugal rotor having a disc stack according to the invention, fig 2 shows part of the disc stack in fig 1 in a larger scale, fig 3 shows part of a  
10 disc stack according to the invention in a modified embodiment, fig 4 shows a separation disc seen from above with respect to fig 1, and fig 5 shows an axial section of the separation disc in fig 4.
- 15 Fig 1 shows in axial section a centrifugal rotor of a kind well known to people skilled in the art. An extensive description of the centrifugal rotor and its function can be found in US-A-4 698 053.
- 20 The centrifugal rotor in fig 1 comprises a rotor body 1 that is rotatable around a central axis 2 and that surrounds a separation chamber 3. In the separation chamber 3 there is arranged for rotation with the rotor, coaxially therewith, a disc stack 4 of frusto conical  
25 separation discs. The separation discs are stacked upon each other having their base portions facing in the same direction in the separation chamber 3. Between adjacent separation discs there are arranged in a known manner flow conducting spacing members, so that the separation  
30 discs delimit between themselves a lot of thin flow paths for liquid to be subjected to centrifugal separation in the rotor.

The stack 4 of separation discs is prevented from  
35 rotating relative to the rotor body by several rods 5

(only one is shown in fig 1), which extend through holes in the separation discs and are connected with the rotor body 1 axially on both sides of the disc stack 4.

5 Liquid to be treated in the rotor may be supplied into it through a stationary pipe 6. From a central receiving chamber 7 in the rotor such liquid is conducted further on through passages 8 to the separation chamber 3, in which it flows towards the rotor centre through the  
10 previously mentioned flow paths between the separation discs.

Through outlet channels 9 separated liquid may leave the separation chamber 3 to be conducted away from the rotor  
15 through a paring member 10.

In the above mentioned thin flow paths in the disc stack 4 particles suspended in the liquid and being heavier than the liquid may be separated from the liquid and  
20 slide along the under sides of the separation discs radially outwardly to be collected finally in the radially outermost part of the separation chamber. From there they may be intermittently thrown out from the rotor through outlet openings 11 by axial movement  
25 within the rotor body 1 of an annular slide 12.

Fig 2 shows schematically a part of the disc stack 4 in fig 1 in a larger scale. From this it can be seen that three separation discs 13 are of a different kind than  
30 the other separation discs 14. In a preferred embodiment of the invention the three discs 13 are made of thin sheet metal, whereas the discs 14 are made of plastic. In fig 2 five plastic discs 14 are arranged in each interspace between adjacent sheet metal discs 13.



Fig 3 shows a part of a disc stack according to the invention, in which every second separation disc 13 is made of metal, whereas the other separation discs 14 are made of plastic.

5

Fig 4 and 5 show a separation disc 14 made in one piece out of plastic. Fig 4 shows the separation disc seen from above and fig 5 shows the same in an axial section along a line V-V in fig 4.

10

The separation disc in fig 4 and 5 has spacing members 15 on its upper side made in one piece with the separation disc and spacing members 16 on its under side, formed in the same manner. The separation disc has a number of through holes 17 intended for rods 5 (see fig 1).

15

Separation discs of plastic formed according to fig 4 and 5 are primarily intended to be used in a disc stack composed in accordance with fig 3. In a disc stack of this kind the separation discs 13 of sheet metal may be entirely smooth, i.e. free from spacing members, on both of their sides.

20

Separation discs of plastic for use in a disc stack according to fig 2 may have spacing members only on their upper sides or their under sides. In this case it may be suitable, if flow spaces for liquid are desired along both the upper side and the under side of each metal disc 13, that even the metal discs are provided with spacing members on their upper sides or their under sides in the same way as the plastic discs. Alternatively, one of the plastic discs to be placed adjacent to a metal disc may be formed with spacing members on both its upper side and its under side, so that the

30

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metal discs can be made entirely without spacing members.

5 A further possibility of providing spacing members in a disc stack according to fig 2 is that all the metal discs 13 and every second one of the plastic discs 14 between adjacent metal discs 13 are entirely smooth, i.e. they have no spacing members, whereas all the other plastic discs 14 are formed according to fig 5, i.e.  
10 they have spacing members on both the upper and under sides. In this case the number of plastic discs 14 between adjacent metal discs 13 should be an uneven number, and both of the plastic discs 14 abutting against one and the same metal disc 13 should be formed  
15 in accordance with fig 5.

In the disc stack of fig 2 as well as the disc stack of fig 3 the relatively shape permanent metal discs 13 give effective support through said spacing members to the  
20 plastic discs 14 which have a relatively small shape permanence, so that the latter will not be deformed during rotation of the centrifugal rotor.

25 Instead of being fixed in the circumferential direction of the rotor by means of rods 5 (fig 1) the separation discs may in a conventional manner be guided by an axial column in the rotor centre. Then either the inner edge portions of the separation discs are provided with axially aligned recesses, in which axial ridges on said  
30 column engage, or is the column provided with axial grooves, in which radial protuberances on the inner edges of the separation discs engage.

Guiding of a disc stack according to the invention may  
35 be arranged such that only the separation discs 13

having a relatively large shape permanence are guided by rods 5 or a centre column of the kind just discussed, whereas the other separation discs having a relatively small shape permanence are kept on place by only being  
5 kept squeezed between those of the separation discs which are guided by the rotor body and have a relatively large shape permanence.

Adjacent separation discs can also be formed such that  
10 they engage with each other in a guiding way. Either the above discussed spacing members or separate protuberances and recesses may be formed to fulfill such a guiding function. A guiding arrangement of this kind may suitably be combined with the above discussed possi-  
15 bility of having only the separation discs 13 with a relatively large shape permanence being guided directly by the rotor body.

Within the scope of the invention there is also a possibility of having in a disc stack according to fig 2 some  
20 or all of the plastic discs 14, which are situated between two adjacent metal discs 13, permanently or releasably connected with each other, so that they can be treated as a single unit.

25 All of the separation discs may be formed in a conventional manner with through holes for distributing a supplied liquid mixture to the various disc interspaces or for conducting away a separated liquid from these  
30 disc interspaces.

If desired, the spacing members between the separation discs may be formed separate from and, thus, releasably arranged between the separation discs. Thereby, all of  
35 the separation discs may be formed entirely smooth. For

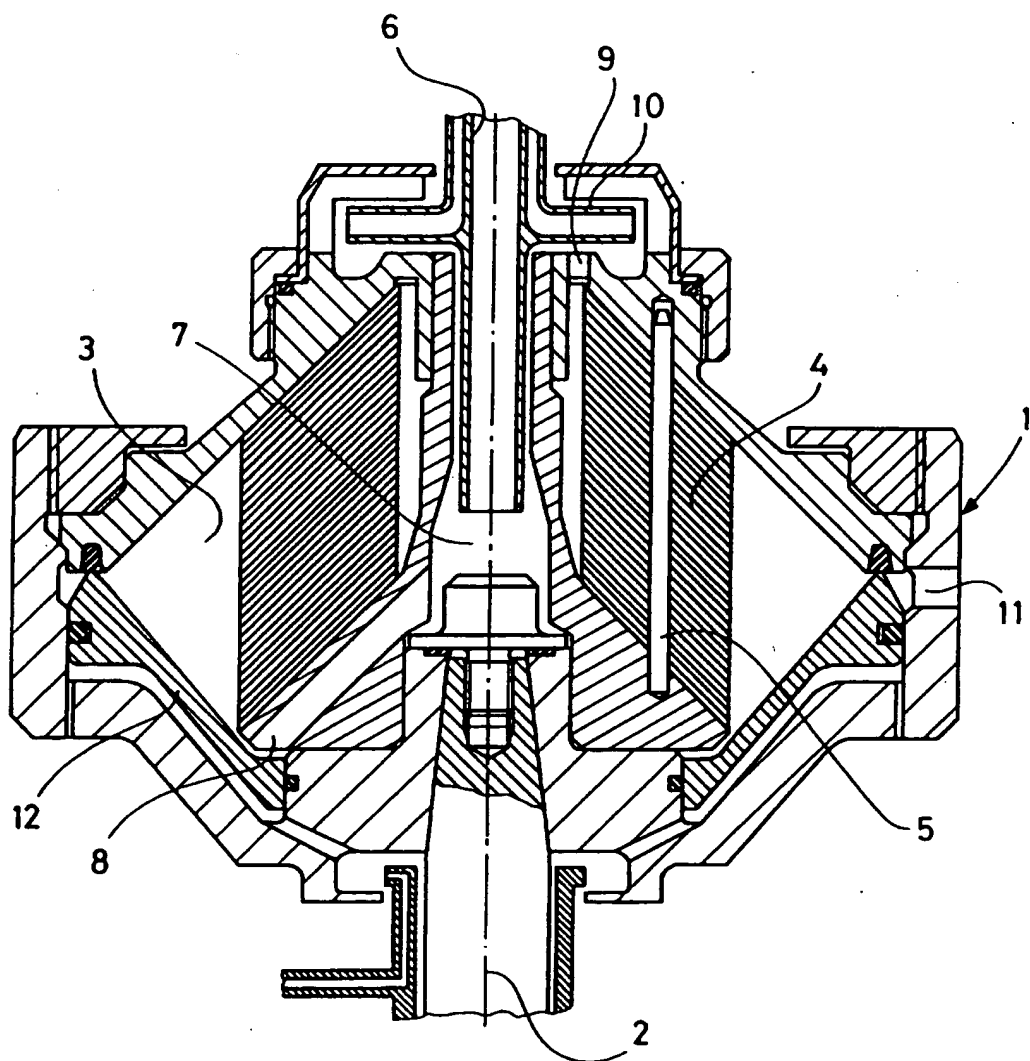
instance, all of the spacing members in each disc interspace may be free from the adjacent separation discs and united with each other by means of a ring arranged concentrically between the separation discs. A  
5 ring of this kind may be formed in one piece with and of the same material, for instance plastic, as the spacing members. The ring together with the spacing members may be fixed relative to the adjacent separation discs in  
10 any suitable manner, e.g. by engaging with rods of the kind shown in fig 1 and designated by 5.

Claims

1. Disc stack of frusto conical separation discs designed to be mounted in the separation chamber of a centrifugal rotor, said discs being stacked upon each other with their base portions facing in the same direction and forming thin separation spaces between adjacent discs, the disc stack comprising separation discs made of a non-metallic material, c h a r a c -  
t e r i z e d i n that the separation discs are of two different kinds with respect to their shape permanence, a separation disc (13) in at least a part of the disc stack having a relatively large shape permanence and being situated between two separation discs (14) having a relatively small shape permanence, the last mentioned separation discs (14) being made of said non-metallic material.
2. Disc stack according to claim 1, which comprises several separation discs of each kind.
3. Disc stack according to claim 2, in which every second separation disc (13) is of a first kind and has a relatively large shape permanence and the other separation discs (14) are of a second kind and have a relatively small shape permanence.
4. Disc stack according to claim 3, in which the separation discs (13) having a relatively large shape permanence are substantially smooth, whereas each one of the other separation discs (14) is formed with protuberances (15,16) forming spacing members between this separation disc (14) and both of the adjacent separation discs (13).

5. Disc stack according to claim 1 or 2, in which several separation discs (14) having a relatively small shape permanence are situated between two adjacent separation discs (13) having a relatively large shape permanence.
6. Disc stack according to claim 5, in which every second separation disc is formed with protuberances forming spacing members between this separation disc and the two adjacent separation discs, whereas the other separation discs, comprising the separation discs (13) having a relatively large shape permanence, are formed substantially without spacing members.
7. Disc stack according to any one of the preceding claims, in which the separation discs (14) having a relatively small shape permanence are made substantially out of plastic.
8. Disc stack according to any one of the preceding claims, in which the separation discs (13) having a relatively large shape permanence are made of substantially metal.
9. Disc stack according to any one of the preceding claims, in which the separation discs (13, 14) of the various kinds have substantially the same thickness.
10. Centrifugal separator comprising a rotor (1) that is rotatable around a central axis (2) and delimits a separation chamber (3), characterized in that a disc stack according to any one of the preceding claims is arranged in the separation chamber (3) for rotation with the rotor (1).

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Fig.1

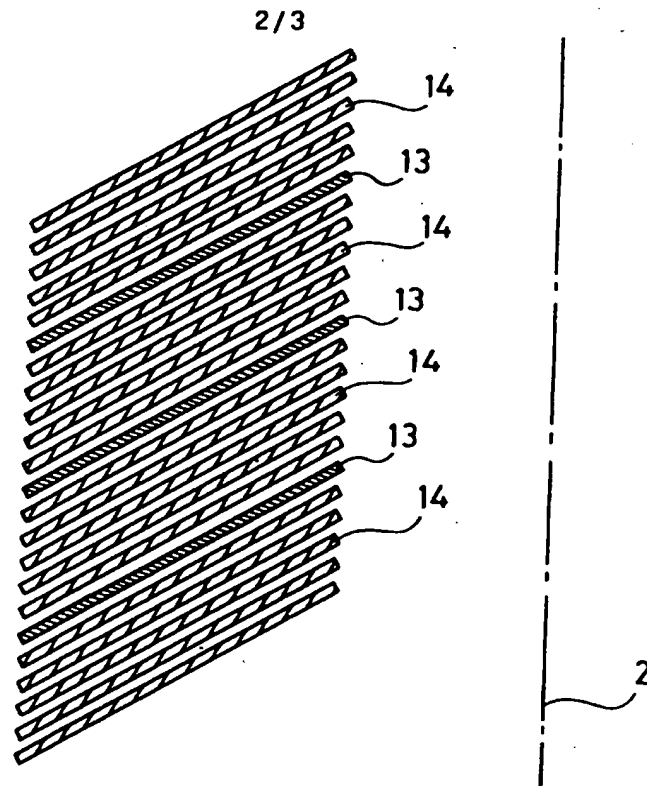


Fig. 2

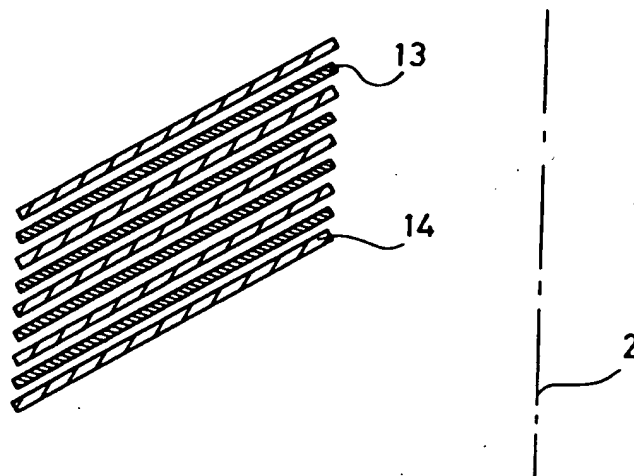
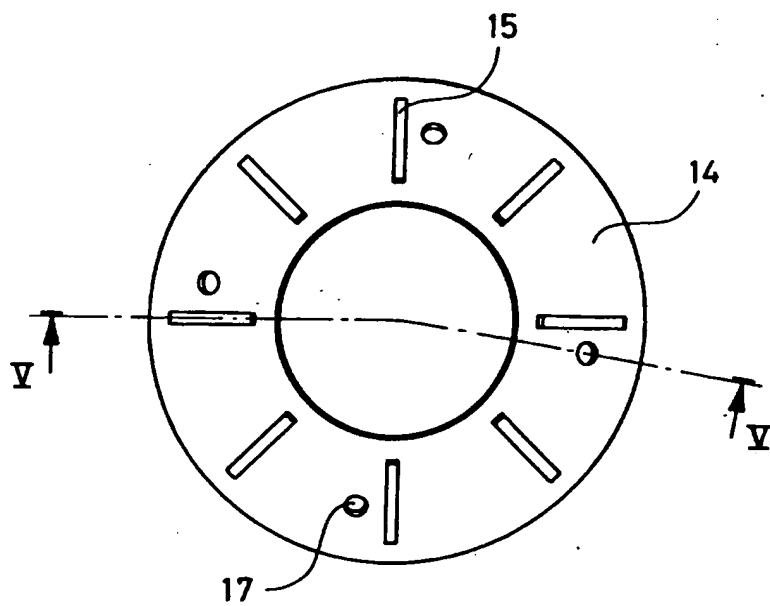
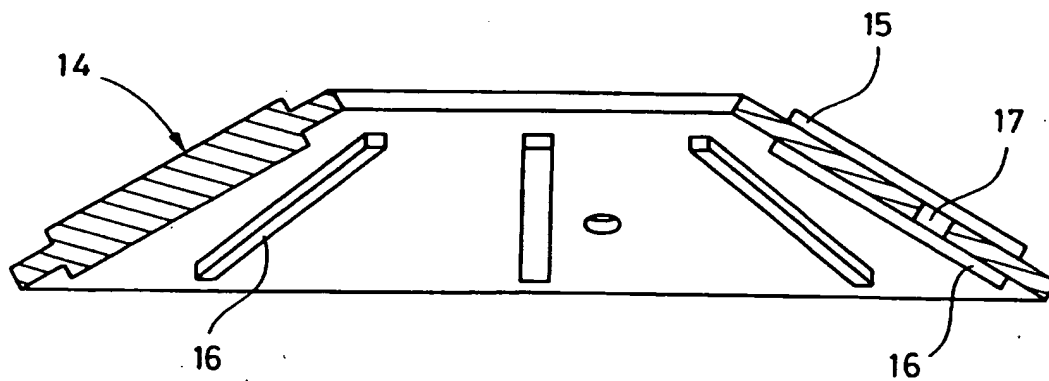


Fig. 3



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Fig. 4Fig. 5

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 96/00234

## A. CLASSIFICATION OF SUBJECT MATTER

IPC6: B04B 1/08, B04B 7/14

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 3335946 A (JAN PUTTERLIK), 15 August 1967 (15.08.67), column 2, line 30 - line 49 --	1
A	DE 3619926 A1 (EURO TECHNICAL OILSERVICES B.V.), 2 January 1987 (02.01.87), column 3, line 17 - line 37, figure 1, claims 1-4 --	1
A	US 3997106 A (MARTIN BARAM), 14 December 1976 (14.12.76), column 1, line 24 - line 49, claim 1, abstract -- -----	1

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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Information on patent family members

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Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US-A-	3335946	15/08/67	FR-A-	1431475	00/00/00
			GB-A-	1098007	00/00/00
DE-A1-	3619926	02/01/87	JP-A-	62030515	09/02/87
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